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(54) METHOD FOR MELTING EXTRA-LOW CARBON STEEL EXCELLENT IN CLEANLINESS

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a melting method of an extra-low carbon steel excellent in the cleanliness, with which the decarburizing speed at the decarburizing treating time under vacuum state is not damaged and reoxidation of molten steel from molten slag in a ladle is restrained and the clogging of an immersion nozzle at the continuous casting time is prevented.

SOLUTION: In the method for producing the extra-low carbon steel by executing deoxidizing treatment after executing the decarburizing treatment to the molten steel in the ladle under vacuum state, the composition of the molten slag in the ladle in the vacuum treating process is adjusted so that the composition of the molten slag in the ladle after completing the deoxidizing treatment becomes by wt.% of 30-60% CaO, ≤10% SiO₂, 20-60% Al₂O₃, 10-20% MgO and 5-15% the total of FeO and MnO.

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CLAIMS

[Claim(s)]

[Claim 1] In the approach of manufacturing super-low carbon steel by carrying out deoxidation processing after carrying out decarbonization processing of the molten steel in a ladle under a vacuum the presentation of the molten slag in the ladle after deoxidation processing termination by weight % CaO: 30-60%, SiO₂ : 10% or less, aluminum 2O₃ : So that the sum total of 20 - 50%, MgO:10-20%, and FeO and MnO may become 5 - 15% The ingot approach of super-low carbon steel of having excelled in vacuum down stream processing at the detergency characterized by adjusting the presentation of the molten slag in a ladle.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the ingot approach especially characterized

by adjustment of the molten slag presentation in the ladle in vacuum down stream processing about the ingot approach of super-low carbon steel excellent in the dergency. [0002]

[Description of the Prior Art] Super-low carbon steel is used for the steel plate for sheathing of the automobile by which it is required that surface discontinuity should be excellent in a moldability few, and in case it is an ingot, super-low carbonization and the cure against the Takakiyo purification of steel are taken.

[0003] As the decarbonization approach at the time of ingotting super-low carbon steel, the method of making non-deoxidized molten steel cause an decarbonization reaction under a vacuum is common. That is, it is decarbonized until carry out tapping of the non-deoxidized molten steel whose carbon content is 0.02 - 0.1 % of the weight to a ladle, it makes the oxygen supplied from the outside, such as oxygen in molten steel, or a slag in a ladle, under a vacuum, and the carbon in molten steel react after that and carbon content becomes 0.001 - 0.005% of the weight from steel-manufacture furnaces, such as a converter.

[0004] It is known that the oxygen content in molten steel required in the case of the above-mentioned decarbonization reaction in order to obtain sufficient decarbonization rate is 0.04 % of the weight or more. When obtaining molten steel with such high oxygen content at steel-manufacture furnaces, such as a converter, the sum total of the content of FeO and MnO which is a low-grade oxide in a slag becomes high with about 15 - 20 % of the weight.

[0005] In the super-low carbon molten steel which performed deoxidation processing by aluminum after decarbonization processing under a vacuum, by the time the continuous casting usually used is completed, aluminum in molten steel and the low-grade oxide in a slag will react. The oxide (aluminum 2O3) of aluminum generates by this reaction. A part of this oxide remains in a cast piece, without being removed from the molten steel in fundish and mold during continuous casting, it serves as nonmetallic inclusion, and worsens the dergency of steel.

[0006] This aluminum 2O3 It may become the surface discontinuity of the steel plate for sheathing of an automobile, and the nonmetallic inclusion of a system may become the cause which is easy to accumulate near the front face of a cast piece, therefore a submerged nozzle blockades during continuous casting. If a submerged nozzle blockades, channeling arises in the molten steel which ***** becomes impossible and productivity is not only checked, but passes through the inside of a submerged nozzle, the flow condition in mold will change, the oxide of aluminum etc. will be accumulated near the front face of a cast piece, and surface discontinuity will arise for a product. In order to prevent lock out of this submerged nozzle furthermore, it will be necessary to increase the flow rate of inert gas, such as Ar blown from the upper part of a submerged nozzle. When the inert gas blown so much is also caught near the front face of a cast piece and remains, it becomes the cause of the surface discontinuity of a product. In order to prevent the surface discontinuity of such a product, taking care of a cast piece and the hot-rolled front face of the material for steel plates poses a big problem from the field of economical efficiency or productivity.

[0007] Then, the cure which lowers before the decarbonization processing under the time of tapping from steel-manufacture furnaces, such as a converter, or a vacuum has been taken [content / of low-grade oxides, such as a lifting, FeO in the slag in a cone ladle, and MnO] in aluminum and the reaction in steel.

[0008] For example, by the approach indicated by JP,5-239537,A, the approach of adding a slag modifier to the slag in the ladle in lapping from a converter or after tapping, making content of the sum total of FeO and MnO in a slag it to 5 or less % of the weight, blowing a top after that before the decarbonization processing under a vacuum, and spraying oxygen gas on the front face of the molten steel in a vacuum tub from a lance is taken.

[0009] Although it blows on the molten steel front face in a vacuum tub a top and oxygen gas

is sprayed from a lance by this approach, that reason is that the oxygen supply from the low-grade oxide contributed to an decarbonization reaction falls, and oxygen required for an decarbonization reaction runs short in order to make low content of the low-grade oxide in the slag before the decarbonization processing under a vacuum by slag reforming. However, with the oxygen gas sprayed on the molten steel front face in a vacuum tub, Fe, Mn, etc. in molten steel oxidize, low-grade oxides, such as FeO and MnO, are generated, and the content of the low-grade oxide in a slag becomes high after all. Moreover, since a lot of modifiers and fluxes are added in tapping in order to make content of the sum total of FeO and MnO in the slag after tapping 5% or less, there are problems, like descent of the molten steel temperature in a ladle is large.

[0010] On the other hand, after decarbonization processing under a vacuum and performing deoxidation processing by aluminum, by adding the flux of an oxide system to the molten steel in a vacuum tub, aluminum and the reaction in steel reduce the content of low-grade oxides, such as a lifting, a cone FeO, and MnO, or the cure which intercepts the slag in a ladle and the interface of molten steel has been taken.

[0011] In JP,3-183722,A, after decarbonization processing under a vacuum and performing deoxidation processing by aluminum, the oxide which uses MgO as a principal component at the molten steel in a vacuum tub is added, and the method of making this oxide placed between the interfaces of a slag and molten steel is indicated. It is the approach of carrying out 2-5kg / molten steel t grade addition of the MgO from tubing immersed in the chute in a vacuum tub, or the ladle besides a vacuum tub.

[0012] By this approach, since there are too many additions of MgO, MgO does not distribute to homogeneity but solidifies in the interface of a slag and molten steel partially, the effectiveness of MgO addition is stabilized, and may not be acquired or the temperature of the molten steel in a ladle may fall greatly. Therefore, it is necessary to spray oxygen gas on the molten steel front face in a vacuum tub, and to raise the temperature of molten steel, and there is a problem that only the steel inferior to a detergency is obtained after all.

[0013]

[Problem(s) to be Solved by the Invention] Without spoiling the decarbonization rate at the time of the decarbonization processing under a vacuum, this invention controls reoxidation of the molten steel from the molten slag in a ladle, and prevents lock out of a submerged nozzle in the case of continuous casting, and aims at offering the approach of ingotting the super-low carbon steel excellent in the detergency.

[0014]

[Means for Solving the Problem] After the summary of this invention carries out decarbonization processing of the molten steel in a ladle under a vacuum, in the approach of manufacturing super-low carbon steel by carrying out deoxidation processing, the presentation of the molten slag in the ladle after deoxidation processing termination is weight %. CaO: 30-60%, SiO₂ : 10% or less, aluminum 2O₃ : So that the sum total of 20 - 50%, MgO:10-20%, and FeO and MnO may become 5 - 15% It is in the ingot approach of super-low carbon steel of having excelled in vacuum down stream processing at the detergency which adjusts the presentation of the molten slag in a ladle.

[0015] The carbon content of the target super-low carbon steel is about 0.005 or less % of the weight of steel in this invention.

[0016] The process of the decarbonization processing under vacuum down stream processing as used in the field of this invention, i.e., a vacuum, and deoxidation processing means down stream processing using ring current mold vacuum processors, such as RH and DH. In order to ingot the super-low carbon steel which was excellent in the detergency with such vacuum down stream processing, it is effective after the deoxidation processing after carrying out decarbonization processing under a vacuum to prevent reoxidation of the

molten steel from the molten slag in a ladle. As mentioned above, in the super-low carbon molten steel which performed deoxidation processing by aluminum, it is because the low-grade oxide in aluminum in molten steel and the molten slag in a ladle reacts.

[0017] In order to prevent reoxidation of the molten steel from the molten slag in a ladle, the approach of intercepting the molten slag in a ladle and the interface of molten steel is the most effective. As an approach of intercepting such an interface, it is most effective to make the molten slag after deoxidation processing crystallize solid phase. It is the molten slag of a liquid phase condition for the reason to contact the molten steel in a ladle directly, and to make molten steel reoxidate, and it is because the reoxidation rate of molten steel falls remarkably in the case of the slag of solid phase and reoxidation of parenchyma and molten steel does not take place to it.

[0018] It carried out the knowledge of the important thing especially that this invention persons choose appropriately the stage to make the molten slag in the ladle after deoxidation processing crystallize this solid phase, namely, aluminum 2O3 rather generated in molten steel after the time of deoxidation processing, and deoxidation processing at this stage rather than reoxidation of the molten steel by molten slag arose until it started continuous casting after deoxidation processing termination etc. -- an oxide surfaces the inside of molten steel and the molten slag in a ladle is adsorbed. That is, reoxidation of the molten steel by the molten slag in a ladle needs to control during the continuous casting after starting continuous casting. That is, if the molten slag in a ladle is made to crystallize solid phase, it is effective for the stage to start the continuous casting after deoxidation processing.

[0019] Furthermore, this invention persons did the knowledge of the ability to make molten slag crystallize solid phase at the stage to start continuous casting by considering the presentation of the molten slag in the ladle after deoxidation processing as the presentation mentioned above.

[0020] Although it changes a little with capacity of the tundish of a ladle and continuous casting, the degree of superheat to the liquidus-line temperature of the temperature of the molten steel in a ladle and the molten steel in tundish is made into the temperature which usually had the degree of superheat of the moderate range. If a degree of superheat is too low, since the temperature in a ladle will fall with time amount, molten steel solidifies quickly and it becomes impossible to cast within a ladle, tundish, or mold in the middle of continuous casting. Moreover, if a degree of superheat is too high, the coagulation husks in mold will fracture and it will become easy to generate a breakout. Furthermore, it is mostly decided with the carbon content of steel that the liquidus-line temperature of a proper will be steel. Therefore, it is desirable for target C [this invention] content to make molten steel temperature in the ladle at the time of continuous casting initiation of 0.005 or less % of the weight of super-low carbon steel about 1590-1620 degrees C. In addition, the temperature of the molten slag which is in contact with the molten steel in a ladle, and molten steel is almost the same.

[0021] When making the molten slag in the ladle after deoxidation processing crystallize solid phase from this with the stage, i.e., the temperature of 1590-1620-degree C molten slag, to start continuous casting, it turned out to reoxidation prevention of molten steel that it is effective.

[0022] If the solid phase of at least 1 - 2 volume % extent is made to crystallize in molten slag at this time, reoxidation of the molten steel by molten slag can be prevented. Since the viscosity of molten slag increases to extent mentioned above and volume % (it is hereafter described as the rate of solid phase) which solid phase crystallizes to molten slag can control the mass transfer by the side of molten slag at least to it, reoxidation of molten steel can be prevented.

[0023]

[Embodiment of the Invention] In order to adjust the presentation of the molten slag in the ladle after deoxidation processing termination to the proper range, it is good to control the outflow of a slag as much as possible, and to add calcined lime, a natural magnesia, a dolomite, lime aluminates, etc. as a flux first, in case tapping of the molten steel is carried out to a ladle from steel-manufacture furnaces, such as a converter. Moreover, in order to adjust the content of the sum total of FeO and MnO in a slag, slag modifiers, such as aluminum ashes and an aluminum-CaO system, may be added.

[0024] The molten steel by which tapping was carried out into the ladle is decarbonization-processed and deoxidation processed with vacuum processors, such as RH and DH. Flux is added to the molten steel in a vacuum tub by this vacuum down stream processing, and the presentation of the molten slag in the ladle after vacuum processing is adjusted.

[0025] Flux can be added after taking about 1 to 3 minutes after addition of deoxidizers, such as aluminum, in case flux is added to the molten steel in a vacuum tub. aluminum 2O3 generated in case deoxidation processing is carried out by aluminum etc. etc. -- it is better to add flux, after returning molten steel after [aluminum addition] 3 minutes or more in order to make molten slag absorb an oxide efficiently. In addition, in order to make flux reach the interface of molten slag and molten steel effectively, it is desirable after addition of flux to continue the ring current of molten steel more than for 2 minutes.

[0026] With the approach of this invention, the molten slag in the ladle after deoxidation processing termination is CaO-aluminum2O3-MgO-SiO2. A system is made into a principal component system, and it adjusts so that it may become the presentation which contains FeO and MnO in this as a low-grade oxide, however, Fe 2O3 of extent mixed from the slag at the time of tapping from a converter etc., P2 O5, and TiO2 etc. -- an unescapable impurity may be included. Below, the presentation of the molten slag in the ladle after deoxidation processing termination is explained concretely.

[0027] CaO is 30 - 60 % of the weight (it is only hereafter described as %), and aluminum 2O3. It may be 20 - 50%. There is little effectiveness which absorbs the oxide generated when CaO carries out deoxidation processing with aluminum etc. in less than 30% of molten slag. Moreover, if it exceeds 60%, the temperature of the molten slag which begins to crystallize solid phase will become higher than the temperature of the range mentioned above.

[0028] aluminum 2O3 At less than 20%, the fluidity of molten slag worsens and the effectiveness which absorbs the oxide generated at the time of deoxidation processing decreases. Moreover, even if it exceeds 50%, the same phenomenon happens.

[0029] CaO and aluminum 2O3 It is the range mentioned above and is aluminum 2O3. Mole-ratio CaO/aluminum 2O3 of receiving CaO When it is two or more, they are MgO or 3 CaO-aluminum 2O3. It becomes easy to crystallize as solid phase. Moreover, this mole ratio is MgO-aluminum 2O3, if aluminum 2O3 is 40% or more less than in two. It becomes easy to crystallize as solid phase.

[0030] MgO may be 10 - 20%. CaO and aluminum 2O3 which were mentioned above It is the range, and when MgO is such range, it becomes easy to crystallize MgO or MgO-aluminum 2O3 as solid phase. MgO cannot crystallize solid phase easily at less than 10%. Since the effectiveness which absorbs the oxide generated when the fluidity of molten slag worsened and carried out deoxidation processing with aluminum etc. will decrease if MgO exceeds 20%, since addition of superfluous flux is caused, the effectiveness is not only saturated, but the temperature fall of molten steel arises. Therefore, MgO may be 10 - 20%.

[0031] SiO2 It may be 10% or less. The temperature which will begin to crystallize solid phase if it exceeds 10% becomes higher than the temperature of the range mentioned

above. In addition, although not limited especially about a minimum, since Si is contained in a flux as a rock, it usually becomes 1% or more.

[0032] The sum total of FeO and MnO is made into 5 - 15%. Although reoxidation of the molten steel from molten slag can be controlled so that there is little sum total of FeO and MnO, it is not necessary to make it fall to 5 etc.% or less which is looked at by the Prior art by the approach of this invention. It is because reoxidation of the molten steel from molten slag can be prevented if solid phase crystallizes to the molten slag in a ladle when it starts continuous casting with 5 - 15%, even if the sum total of FeO and MnO is expensive. Therefore, it is not necessary to become unnecessary [addition of a superfluous slag modifier], and to spray oxygen gas on the front face of the molten steel in a vacuum tub, without delaying the decarbonization rate at the time of the decarbonization processing under a vacuum. However, if it exceeds 15%, reoxidation of molten steel will tend to take place. At less than 5%, it becomes impossible to secure the 0.04% or more of the amounts of oxygen in molten steel required for the decarbonization reaction under a vacuum, and an decarbonization reaction not only becomes slow, but may not be able to perform the ingot of super-low carbon steel.

[0033] By the way, since the gestalt of solid phase and crystallized volume % crystallized to molten slag can be presumed now in recent years using thermodynamic count software, it should just utilize these.

[0034] The flux added to the molten steel in a vacuum tub is molten slag to MgO or MgO-aluminum 2O3. When making solid phase crystallize, MgO system clinkers, such as a natural magnesia, a dolomite clinker, the brick waste with same these and presentation, etc. are good. Moreover, 3 CaO-aluminum 2O3 When making solid phase crystallize, the brick waste with these same calcined lime which uses CaO as a principal component, dolomite, clinker and these, and presentations is good.

[0035] The particle size of the flux to add has that good by which 90% or more enters among 1-30mm. In less than 1mm, it is drawn in the exhaust air system of a vacuum processor. Moreover, it rises to surface near the dip tube immediately, without homogeneity distributing, even if it will not be invaded into flux by molten steel at the time of addition, and it will not be carried in, if it exceeds 30mm, but remains on the molten steel front face in a vacuum tub or is conveyed by molten steel up to the outside of a vacuum tub, and becomes a lump.

[0036] Although the addition of flux is based on the presentation of the slag in the ladle before decarbonization processing, an amount, etc., it is good to be referred to as 2kg or less per molten steel t. It is because the fall of molten steel temperature becomes large, so the need of spraying oxygen gas on the molten steel front face of a vacuum tub, and raising the temperature of molten steel on the contrary will come out if it adds exceeding 2kg.

[0037]

[Example] Corresponding to the trial shown in Table 1 which mentions 270t super-low carbon steel later, 8 *****'s was ingoted using the converter and RH vacuum processor (it is only hereafter described as RH). The molten steel temperature in the ladle after 0.02 - 0.06% of C, 0.01 - 0.2% of Mn, 0.01 - 0.03% of Si, and tapping of the chemical composition of the molten steel before the vacuum processing after [a converter to] tapping was 1660-1690 degrees C. In addition, in order to make adjustment of a next slag presentation more reliable on the occasion of tapping, the slag outflow from a converter was controlled as much as possible. To the molten slag in the ladle just behind tapping, the natural magnesia was added as a flux and aluminum ashes and aluminum-CaO system flux were suitably added as a slag modifier.

[0038] Next, using RH, decarbonization processing was performed under the vacuum until the carbon content in molten steel became 0.005% or less. It deoxidized by having added aluminum to the molten steel in a vacuum tub after that, and aluminum content in molten

steel was adjusted to 0.02 - 0.06%.

[0039] The sample of the molten slag in a ladle was extracted before decarbonization processing, X-ray fluorescence was performed, and the presentation of molten slag was checked. In order to refer to the presentation of the checked molten slag and to adjust the presentation of the molten slag after deoxidation processing, the flux of a dolomite clinker or a natural magnesia was added to the molten steel in a vacuum tub after [of aluminum addition for deoxidation processing] about 6 minutes using alloy addition equipment. What goes into the range of 1-13mm 95% was used for the particle size of flux. The ring current of molten steel was performed for [of flux] about 4 minutes after addition. Then, the sample of the molten slag in a ladle was extracted and X-ray fluorescence was performed.

[0040] Moreover, it was made to be in a liquid phase condition with the uniform part which holds molten steel temperature at 1600 degrees C or more, and contacts the molten steel of molten slag through down stream processing in RH.

[0041] Continuous casting of the molten steel after deoxidation processing termination was carried out to the cast piece of the thickness of 250mm, and a cross-section configuration with a width of face of 1250mm.

[0042] The prevention effectiveness of reoxidation of molten steel was evaluated by calculating value deltaaluminum which deducted aluminum content in the molten steel in the tundish measured during continuous casting from aluminum content in the molten steel after deoxidation processing termination. Moreover, the molten steel in fundish was extracted and the total amount of oxygen in molten steel was measured.

[0043] The cross-section sample was extracted from the obtained cast piece, and the total amount of oxygen and cleanliness of a cast piece were investigated. The total amount of oxygen of a cast piece analyzed the total amount of oxygen of three samples extracted from the location of directly under [of a cross-section sample / surface], 1/4 thickness, and 1/2 thickness, and calculated it by the average. The cleanliness of a cast piece is JIS. G 10cm² which followed the test method specified to 0555 and were extracted from the front face of a cast piece in the location less than 10mm directly under a front face It investigated by carrying out microscope observation of the sample of *****-ed by 400 times. By making into a characteristic 1.00 the results of an investigation of the cleanliness of the cast piece of trial No.1 of the example of this invention mentioned later, indexation of the results of an investigation of the cleanliness of the cast piece of other trials was carried out, and they were evaluated.

[0044] Moreover, using the presentation of the molten slag analyzed after adjusting a slag presentation after deoxidation processing, thermodynamic count software was used and the gestalt and the rate of solid phase of solid phase which are crystallized to molten slag with the fall of the temperature of molten slag were computed.

[0045] A test condition and a test result are shown in Table 1.

[0046]

[Table 1]

表1

試験 No.	取 烷 内 の フ ラ グ 組 成 (重量%)							Δ Al *1 (%)	タングステン 内の溶鋼 中の全酸素 量 (ppm)	铸片の 溶合度 の指標 (ppm)	铸片の 溶合度 の指標 (-)	スラグに 漏出する 酸素の 割合 (%)	
	CaO	SiO ₂	Al ₂ O ₃	MgO	FeO	MnO	FeO+MnO						
本 發明 例	1	38.9	8.1	31.8	10.0	4.8	2.8	7.6	0.002	27	19	1.00	1.0
	2	38.1	8.9	29.1	12.1	7.8	3.2	11.0	0.002	24	18	0.98	2.8
	3	38.5	9.1	28.6	12.8	7.4	3.1	10.5	0.003	25	17	1.00	2.3
	4	37.4	7.4	35.2	12.1	3.5	1.8	5.3	0.002	24	18	0.97	1.6
	5	35.4	8.9	30.6	12.3	7.0	3.2	10.2	0.001	21	18	0.94	5.1
	6	40.2	8.1	25.6	16.1	5.6	3.2	8.8	0	22	16	0.92	8.7
比較 例	7	39.6	8.1	39.2	6.7	2.6	3.8	6.4	0.01	45	35	1.46	0
	8	34.5	7.6	38.2	7.4	7.1	3.3	10.4	0.013	51	33	1.88	0

*1：脱酸处理終了後の溶鋼中のAl含有率からタンディッシュ内の溶鋼中のAl含有率を引いた値。

[0047] In trial No. 1-6 of the example of this invention, the presentation of the molten slag in the ladle after deoxidation processing termination was considered as the presentation of the range specified by this invention. The value of deltaaluminum which shows extent of reoxidation of the molten steel in these trials was as low as 0.003% or less, tundish and the total amount of oxygen of a cast piece were also as low as 30 and 20 ppm or less respectively, and the cleanliness of a cast piece was also 1.00 or less characteristic, and was a result with good all.

[0048] It is because solid phase crystallized to the molten slag in a ladle after continuous casting initiation that had little reoxidation of molten steel and whose cleanliness of the total amount of oxygen of molten steel and a cast piece etc. was good although the content of the sum total of FeO and MnO in the molten slag in the ladle after deoxidation processing termination was as high as 5 - 11%. That is, in the result computed using thermodynamic count software from the analysis value of a presentation of the molten slag after adjusting a presentation, it has presumed that solid phase did not crystallize to the molten slag in a ladle, but the solid phase of a MgO phase had crystallized about 1 to 9% after continuous casting initiation before continuous casting termination from after deoxidation processing termination before initiation of continuous casting.

[0049] It reached trial No.5, and **aluminum was low, molten steel and the total amount of oxygen of a cast piece were also low at 6, and the cleanliness characteristic of a cast piece was also the good result of presuming solid phase to have crystallized mostly especially in 0.95 or less low value.

[0050] The example of a comparison reached trial No.7 and it considered as the presentation out of range which specifies the presentation of the molten slag in the ladle after deoxidation processing termination by this invention in 8. MgO content is low at trial No.7, and it is aluminum 2O3 further at trial No.8. Mole-ratio CaO/aluminum 2O3 of receiving CaO In spite of being less than two, it is aluminum 2O3. Content considered as less than 40% of presentation of each molten slag. Therefore, the last stage of continuous casting has also been presumed that solid phase does not crystallize to molten slag.

[0051] The value of deltaaluminum which shows extent of reoxidation of the molten steel of these trial No.7 and No.8 was as high as 0.01% or more, the molten steel in tundish and the total amount of oxygen of a cast piece were also as high as 40 and 30 ppm or more respectively, and the cleanliness of a cast piece was also 1.00 or more characteristics, and was results with bad all.

[0052] Drawing 1 is drawing showing the effect the presentation of the molten slag in the ladle after deoxidation processing termination affects reoxidation of molten steel. It is the aluminum content 0 in the molten steel immediately after deoxidation processing termination [aluminum] about aluminum content in the molten steel in the tundish under continuous casting [aluminum]. The value [aluminum]/0 which **(ed) Relation with continuous casting time amount is shown about trial No.1, and 5, 6 and 8.

[0053] In trial No.1 which can be presumed that solid phase crystallizes at least 1% to molten slag as compared with trial No.8 presumed that solid phase does not crystallize to molten slag, reoxidation of molten steel is understood that the effectiveness of reoxidation prevention of molten steel is remarkable as it is controlled and its rate of solid phase increases like trial No.5 and No.6 further.

[0054]

[Effect of the Invention] By application of the approach of this invention, reoxidation of the molten steel from the molten slag in a ladle can be controlled, without spoiling the decarbonization rate at the time of the decarbonization processing under a vacuum. Moreover, lock out of a submerged nozzle can be prevented in the case of continuous casting, and it is still more possible to ingot the super-low carbon steel excellent in the durgency. It cannot be overemphasized that **** prevention and **** prevention can be performed by selection of suitable flux. Moreover, it becomes reducible [a manufacturing cost] from such effectiveness.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The presentation of the molten slag in the ladle after deoxidation processing termination is drawing showing the effect affect reoxidation of molten steel.

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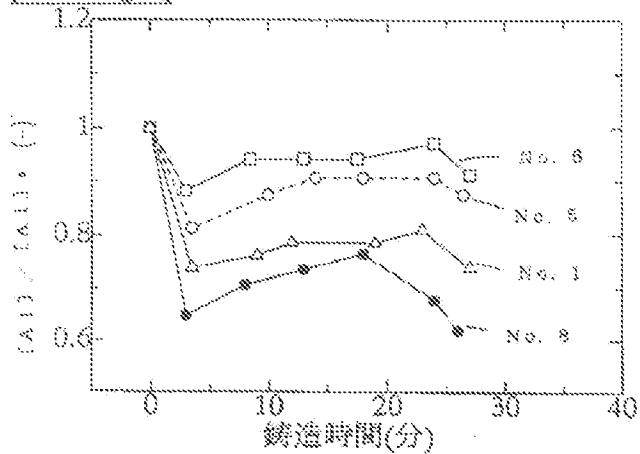
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DRAWINGS

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(54) 【発明の名称】 清浄性に優れた極低炭素鋼の溶製方法

(57) 【要約】

【課題】 清浄性に優れた極低炭素鋼の溶製方法の提供。

【解決手段】 真空下で取鍋内の溶鋼を脱炭処理した後、脱酸処理することにより極低炭素鋼を製造する方法において、脱酸処理終了後の取鍋内の溶融スラグの組成が、重量%で、CaO: 3.0~6.0%, SiO₂: 1.0%以下、Al₂O₃: 2.0~5.0%, MgO 1.0~2.0%ならびにFeOおよびMnの合計が9~1.9%となるように、真空処理工程で取鍋内の溶融スラグの組成を調整する。

【特許請求の範囲】

【請求項1】真空中で取鍋内の溶鋼を脱炭処理した後、脱炭処理することにより極低炭素鋼を製造する方法において、脱炭処理終了後の取鍋内の溶融スラグの組成が、重量%で、 $\text{C}_{\text{m}\text{o}}$ ：3.0～6.0%、 SiO_2 ：1.0%以下、 Al_2O_3 ：2.0～5.0%、 MnO ：1.0～2.0%ならびに FeO および MnO の合計が5.0～15.0%となるように、真空処理工程で取鍋内の溶融スラグの組成を調整することを特徴とする清浄性に優れた極低炭素鋼の溶製方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、清浄性に優れた極低炭素鋼の溶製方法に関するものとし、特に真空処理工程での取鍋内の溶融スラグ組成の調整を特徴とする溶製方法に関するものである。

【0002】

【従来の技術】表面欠陥が少なくかつ成形性に優れていることが要求される自動車の外装用鋼板には、極低炭素鋼が用いられており、溶製の際に、鋼の極低炭素化および高精錬化対策が採られている。

【0003】極低炭素鋼を溶製する際の脱炭方法としては、真空中でお脱炭溶鋼に脱炭反応をおこさせる方法が一般的である。すなわち、転炉等の製鋼炉より炭素含有率が約0.2～約1.0重量%の未脱炭溶鋼を取鍋に出鋼し、その後、真空中で溶鋼中の酸素または取鍋内のスラグなどの外部から供給される酸素と溶鋼中の炭素とを反応させ、炭素含有率が約0.001～約0.005重量%になるまで脱炭する。

【0004】上記の脱炭反応の際に、十分な脱炭速度を得るために必要な溶鋼中の酸素含有率は約0.04重量%以上であることが知られている。このような酸素含有率の高い溶鋼を転炉等の製鋼炉で得る場合、スラグ中の低級酸化物である FeO と MnO の含有率の合計が1.0～2.0重量%程度と高くなる。

【0005】真空中での脱炭処理後に Al_2O_3 による脱炭処理を行った極低炭素溶鋼では、通常用いられる連続鍛造が終了するまでの間に、溶鋼中の Al_2O_3 とスラグ中の低級酸化物が反応する。この反応により Al_2O_3 の酸化物(Al_2O_3)が生成する。この酸化物の一部は連続鍛造中にクンディッシュ内や鍛型内の溶鋼から除去されずに錫片に残存して非金属介在物となり、鋼の清浄性を悪化させる。

【0006】この Al_2O_3 系の非金属介在物は、錫片の表面近傍に集積しやすく、そのため自動車の外装用鋼板の表面欠陥となったり、また、連続鍛造中に浸漬ノズルが閉塞する原因となったりする場合がある。浸漬ノズルが閉塞すると連続鍛造ができなくなり、生産性が阻害されるばかりでなく、浸漬ノズル内を通過する溶鋼に偏流が生じて新壁内の流動状態が変化し、 Al_2O_3 の酸化物など

が錫片の表面近傍に集積し、製品に表面欠陥が生じる。さらにこの浸漬ノズルの閉塞を防ぐために、浸漬ノズルの上部より吹き込まれる Ar 等の不活性ガスの流量を増加する必要が生じる。多量に吹き込まれた不活性ガスもし、錫片の表面近傍に捕捉され、残留した場合には、製品の表面欠陥の一因となる。このような製品の表面欠陥を防止するために、錫片や熱間圧延した鋼板用素材の表面を手入れすることは、経済性や生産性の面から大きな問題となる。

【0007】そこで、鋼中の Al_2O_3 と反応を起こしやすい取鍋内のスラグ中の FeO や MnO などの低級酸化物の含有率を、転炉等の製鋼炉からの出鋼時、または真空中での脱炭処理前に下げる対策が採られてきた。

【0008】たとえば、特開平1-239537号公報に開示される方法では、転炉からの出鋼中または出鋼後の取鍋内のスラグに、スラグ改質剤を添加してスラグ中の FeO および MnO の合計の含有率を約重0.5%以下にし、その後、真空中での脱炭処理前に上吹きランスから真空槽内の溶鋼の表面に酸素ガスを吹き付ける方法を採っている。

【0009】この方法では、真空槽内の溶鋼表面に上吹きランスから酸素ガスを吹き付けるが、その理由は、スラグ改質により真空中での脱炭処理前のスラグ中の低級酸化物の含有率を低くするため、脱炭反応に密接する低級酸化物からの酸素供給量が低下して、脱炭反応に必要な酸素が不足するからである。しかし、真空槽内の溶鋼表面に吹き付けられる酸素ガスにより、溶鋼中の FeO や MnO などが酸化され、 FeO や MnO などの低級酸化物が発生し、結局スラグ中の低級酸化物の含有率が高くなる。また、出鋼後のスラグ中の FeO および MnO の合計の含有率を約0.5%以下にするために、多量の改質剤および溶滓剤を出鋼中に添加するので、取鍋内の溶鋼温度の降低が大きいこととの問題がある。

【0010】一方、真空中での脱炭処理後に Al_2O_3 による脱炭処理を行った後に、真空槽内の溶鋼に酸化物系の溶渣剤を添加することにより、鋼中の Al_2O_3 と反応を起こしやすい FeO や MnO などの低級酸化物の含有率を低下させたり、取鍋内のスラグと溶鋼の界面を遮断する対策などが採られてきた。

【0011】特開平3-183722号公報では、真空中での脱炭処理後に Al_2O_3 による脱炭処理を行った後に、真空槽内の溶鋼に MgO を主成分とする酸化物を添加し、スラグと溶鋼の界面に、この酸化物を介在させる方法が開示されている。 MgO を、真空槽内のショートまたは真空槽外の取鍋内に浸漬した管から、2～5mm／溶鋼の程度添加する方法である。

【0012】この方法では、 MgO の添加量が多すぎるので、 MgO がスラグと溶鋼の界面に均一に分散せず、部分的に固まつたりして、 MgO 添加の効果が発現して得られなかつたり、取鍋内の溶鋼の温度が大きく低下す

る場合がある。そのため、真空槽内の溶鋼表面に酸素ガスを吹き付けて溶鋼の温度を上げる必要があり、結局、清浄性に劣る鋼しか得られないという問題がある。

【0013】

【発明が解決しようとする課題】本発明は、真空中での脱炭処理時の脱炭速度を保たうことなく、また、取鍋内の溶融スラグからの溶鋼の再酸化を抑制し、かつ連続鋳造の際に浸没ノズルの堵塞を防止して、清浄性に優れた極低炭素鋼を溶製できる方法を提供することを目的とする。

【0014】

【課題を解決するための手段】本発明の要旨は、真空中で取鍋内の溶鋼を脱酸処理した後、脱酸処理することにより極低炭素鋼を製造する方法において、脱酸処理終了後の取鍋内の溶融スラグの組成が、重量%で、CaO: 3.0~6.0%、SiO₂: 1.0%以下、Al₂O₃: 2.0~4.0%、MgO: 1.0~2.0%ならびにFeOおよびMnOの合計が1.5%となるように、真空中処理工程で取鍋内の溶融スラグの組成を調整する清浄性に優れた極低炭素鋼の溶製方法にある。

【0015】本発明で対象とする極低炭素鋼とは、炭素含有率がおよそ0.005重量%以下の鋼である。

【0016】本発明でいう真空中処理工程、すなわち、真空中での脱炭処理および脱酸処理の工程とは、RHやDHHなどの環流型真空中処理装置を用いた処理工程を意味する。このような真空中処理工程により清浄性に優れた極低炭素鋼を溶製するには、真空中で脱炭処理した後の脱酸処理後に、取鍋内の溶融スラグからの溶鋼の再酸化を防止することが効果的である。上述したように、Alによる脱酸処理を行った極低炭素溶鋼では、溶鋼中のAlと取鍋内の溶融スラグ中の低級酸化物が反応するからである。

【0017】取鍋内の溶融スラグからの溶鋼の再酸化を防止するには、取鍋内の溶融スラグと溶鋼の界面を遮断する方法が最も効果的である。このような界面を遮断する方法としては、脱酸処理後の溶融スラグに固相を晶出させるのが、最も効果的である。その理由は、取鍋内の溶鋼と直接接触して溶鋼を再酸化させているのは、液相状態の溶融スラグであり、固相のスラグの場合には、溶鋼の再酸化速度が著しく低下し、実質、溶鋼の再酸化は起こらないからである。

【0018】本発明者らは、脱酸処理後の取鍋内の溶融スラグにこの固相を晶出させる時期を適切に選択することが、ときに重要なことを知見した。すなわち、脱酸処理終了後から連続鋳造を開始するまでは、溶融スラグによる溶鋼の再酸化が生じるよりも、むしろ、この時期には、脱酸処理時および脱酸処理後に溶鋼中に生成したAl₂O₃などの酸化物が、溶鋼中を浮上して取鍋内の溶融スラグによる溶鋼の再酸化は、連続鋳造を開始した後の

連続鋳造中に抑制する必要である。すなわち、脱酸処理後の連続鋳造を開始する時期に、取鍋内の溶融スラグに固相を晶出させれば効果的である。

【0019】さらに、本発明者らは、脱酸処理後の取鍋内の溶融スラグの組成を、上述した組成とすることにより、連続鋳造を開始する時期に溶融スラグに固相を晶出させることができることを知見した。

【0020】取鍋および連続鋳造のタンディッシュの容積によって若干異なるが、取鍋内の溶鋼およびタンディッシュ内の溶鋼の温度の液相線温度に対する過熱度は、通常、過度の範囲の過熱度を持った温度とする。過熱度が低すぎると、取鍋内の温度が時間とともに低下するため、連続鋳造の途中で、溶鋼が取鍋、タンディッシュまたは鋳型内で、急速に凝固して、鋳造できなくなる。また、過熱度が高すぎると、鋳型内の凝固殻が剥離してブレーカウトが発生しやすくなる。さらに、鋼に固有の液相線温度は、鋼の炭素含有率によって報復する。したがって、本発明が対象とするC含有率が0.005重量%以下の極低炭素鋼の連続鋳造開始時の取鍋内の溶鋼温度は、1590~1620°C程度とするのが望ましい。なお、取鍋内の溶鋼に接している溶融スラグと溶鋼の温度は、ほぼ同じである。

【0021】のことから、連続鋳造を開始する時期、すなわち、1590~1620°Cの溶融スラグの温度で、脱酸処理後の取鍋内の溶融スラグに固相を晶出せれば、溶鋼の再酸化防止に対して効果的であることが分かった。

【0022】このとき、溶融スラグ中に、少なくとも1~2体様の程度の固相を晶出せれば、溶融スラグによる溶鋼の再酸化を防止できる。固相が溶融スラグに晶出する体積%（以下、固相率と記す）が、上述した程度に少なくとも、溶融スラグの粘性は増大し、溶融スラグの物質移動を抑制できるので、溶鋼の再酸化を防止できる。

【0023】

【発明の実施の形態】脱酸処理終了後の取鍋内の溶融スラグの組成を適正な範囲に調整するために、まず、転炉などの製鋼炉から溶鋼を取鍋に出鋼する際、スラグの流出ができるだけ抑制し、かつ造渣剤として生石灰、天然マグネシア、ドロマイト、ライムアルミニートなどを添加するのがよい。また、スラグ中のFeOおよびMnOの合計の含有率を調整するために、Al₂O₃とCaOなどのスラグ改良剤を添加してもよい。

【0024】取鍋内に出鋼された溶鋼は、RHやDHHなどの真空中処理装置により、脱炭処理および脱酸処理される。この真空中処理工程で真空中槽内の溶鋼に媒溶剤を添加して、真空中処理後の取鍋内の溶融スラグの組成を調整する。

【0025】真空中槽内の溶鋼に媒溶剤を添加する際に、Al₂O₃などの脱酸剤の添加後1~3分程度してから、媒溶

剤を添加できる。A₁などにより脱酸処理する際に生成するAl₂O₃などの酸化物を溶融スラグに効率的に吸収させるためには、A₁添加後3分以上溶解を繼續した後に媒溶剤を添加する方がよい。なお、媒溶剤を効果的に溶融スラグと溶解の界面に到達させるためには、媒溶剤の添加後、2分程度上溶解の環流を継続することが望ましい。

【0026】本発明の方法では、脱酸処理終了後の取扱内の溶解スラグが、CaO·Al₂O₃·MgO-SiO₂系を主成分系とし、これに低級酸化物としてFeOおよびMnOを含む組成となるように調整する。ただし、転炉などからの出鋼時のスラグから混入する程度のFe₂O₃、P₂O₅、TiO₂などの不規則的不純物を含んでも構わない。以下に、脱酸処理終了後の取扱内の溶解スラグの組成を具体的に説明する。

【0027】CaOは30~60の重量%（以下、単に%と記す）、Al₂O₃は20~50%とする。CaOが30%未満の溶解スラグでは、A₁などで脱酸処理する時に生成する酸化物を吸収する効果が少ない。また、60%を超えると、固相を晶出し始めの溶解スラグの温度が、上述した範囲の温度よりも高くなる。

【0028】Al₂O₃が20%未満では、溶解スラグの流动性が悪くなり、脱酸処理時に生成した酸化物を吸収する効果が少なくなる。また、50%を超えても、同様の現象が起こる。

【0029】CaOおよびAl₂O₃が上述した範囲であって、Al₂O₃に対するCaOのモル比CaO/Al₂O₃が2以上の場合、MgOまたは3CaO·Al₂O₃が固相として晶出しやすくなる。また、このモル比が2未満では、Al₂O₃が46%以上であれば、MgO·Al₂O₃が固相として晶出しやすくなる。

【0030】MgOは10~20%とする。上述したようなCaOおよびAl₂O₃の範囲で、かつMgOがこのような範囲の場合には、MgOまたはMgO·Al₂O₃が固相として晶出しやすくなる。MgOが10%未満では固相が晶出しない。MgOが20%を超えると溶解スラグの流动性が悪くなり、A₁などで脱酸処理した時に生成した酸化物を吸収する効果が少なくなるので、その効果が期待するばかりでなく、過剰な媒溶剤の添加を招いていることから、溶解の温度低下が生じる。したがって、MgOは10~20%とする。

【0031】SiO₂は10%以下とする。10%を超えると固相を晶出し始めの温度が、上述した範囲の温度よりも高くなる。なお、下限については、とくに規定しないが、Siは脱石として造渣剤に含まれるので、通常1%以上となる。

【0032】FeOおよびMnOの合計は5~15%とする。FeOおよびMnOの合計が少ないほど溶解スラグからの溶解の再酸化が抑制できるが、本発明の方法では、従来の技術に見られるようなら%以下などに低下さ

せなくてもよい。FeOおよびMnOの合計が5~15%と高くても、連続鍛造を開始する時点で、取扱内の溶解スラグに固相が晶出すれば、溶解スラグからの溶解の再酸化を防止できるからである。したがって、真空中での脱酸処理時の脱炭速度を遅らせることなく、過剰なスラグ改質剤の添加も不要となり、また、真空槽内の溶解の表面に酸素ガスを吹き付ける必要もない。ただし、15%を超えると、溶解の再酸化が起こりやすい。15%未満では、真空中での脱炭反応に必要な溶解中の酸素量0.04%以上を確保できなくなり、脱炭反応が遅くなるばかりでなく、精练炉溶解の溶解ができない場合がある。

【0033】ところで、溶解スラグに晶出する固相の形態および晶出した体積率は、近年、熱力学的計算ソフトウェアを利用して推定することができるようになってきたので、これらを活用すればよい。

【0034】真空槽内の溶解に添加する媒溶剤は、溶解スラグからMgOまたはMgO·Al₂O₃の固相を晶出させる場合には、天然マグネシアなどのMgO系クリンカー、ドロマイトクリンカーおよびこれらと組みか同じレンガ塊などが多い。また、3CaO·Al₂O₃の固相を晶出せる場合には、CaOを主成分とする生石膏、ドロマイト、これらのクリンカーおよびこれらと組みか同じレンガ塊が多い。

【0035】添加する媒溶剤の粒径は、1~30mmの間に90%以上が入るものが多い。1mm未満では、真空中処理装置の排気系に引き込まれる。また、30mmを超えると、媒溶剤は添加時に溶解に侵入、攪拌されず、真空槽内の溶解表面に残留したり、または真空槽外までは溶解により搬送されても、均一に分散されずに、ただちに浸漬管近傍で浮上して、固まりとなったりする。

【0036】媒溶剤の添加量は、脱炭処理前の取扱内のスラグの組成、量などにもよるが、溶解も当たり2kg以下とするのがよい。2kgを超えて添加すると、溶解温度の低下が大きくなるため、かえって、真空中槽の溶解表面に酸素ガスを吹き付けて、溶解の温度を上げる必要が出てくるからである。

【0037】

【実施例】転炉および日立真空処理装置（以下、単に良目と記す）を用いて、270tの極低炭素鋼を後述する表1に示す試験に対応してスチール溶製した。転炉から出鋼後の真空処理前の溶解の化学組成は、CaO:0.9~0.06%、MnO:0.1~0.2%、SiO₂:0.1~0.03%、出鋼後の溶解内の溶解温度は1660~1690℃であった。なお、出鋼に際して、後のスラグ組成の調整をより確実にするために、転炉からのスラグ流出を極力抑制するようにした。出鋼直後の取扱内の溶解スラグに、造渣剤として天然マグネシアを、スラグ改質剤として、A₁灰、A₁-CaO系フランクスを適宜添加した。

【0038】次に、丸目を用いて、溶鋼中の炭素含有率が0.605%以下となるまで真空中で脱酸処理を行った。その後に、真空中の溶鋼中のAlを添加して脱酸を行い、溶鋼中のAl含有率を0.02~0.06%に調整した。

【0039】脱酸処理前に取鍋内の溶融スラグのサンプルを採取し、蛍光X線分析を行って溶融スラグの組成を確認した。確認した溶融スラグの組成を参考にして、脱酸処理後の溶融スラグの組成を調整するために、脱酸処理のためのAl添加から約6分後に、ドロマイトクリンカーや天然マグイシアの媒溶剤を、合金添加装置を利用して真空中の溶鋼に添加した。媒溶剤の粒径は、1~1.3mmの範囲にうらぎ入るもの用いた。媒溶剤の添加後約4分間、溶鋼の攪拌を行った。その後、取鍋内の溶融スラグのサンプルを採取し、蛍光X線分析を行った。

【0040】また、丸目の処理工程を通じて、溶鋼温度を1600°C以上に保持して溶融スラグの溶鋼と接触する部分が均一な液相状態であるようにした。

【0041】脱酸処理終了後の溶鋼を、厚み25.0mm、軸125.0mmの断面形状の鑄片に連続鍛造した。

【0042】溶鋼の再酸化の防止効果は、脱酸処理終了後の溶鋼中のAl含有率から連続鍛造中に測定したタン

ディッシュ内の溶鋼中のAl含有率を差し引いた値(ΔAl)を求ることにより評価した。また、タンディッシュ内の溶鋼を採取し、溶鋼中の全酸素量を測定した。

【0043】得られた鑄片から横断面サンプルを採取し、鑄片の全酸素量および清浄度を調査した。鑄片の全酸素量は、横断面サンプルの表面直下、1/4厚および1/2厚の位置から採取した3個の試料の全酸素量を分析し、その平均値で求めた。鑄片の清浄度は、JIS G 0901に規定する試験方法に則り、鑄片の表面から表面直下1.0mm以内の位置で採取した1.0cm²の表面積の試料を40の倍で鏡面鏡観察することにより調査した。後述する本発明例の試験No.1の鑄片の清浄度の調査結果を指数1.00として、他の試験の鑄片の清浄度の調査結果を指数化して評価した。

【0044】また、脱酸処理後にスラグ組成を調整した後の、分析した溶融スラグの組成を用いて、熱力学的計算ソフトウエアを利用して、溶融スラグの温度の低下とともに溶融スラグに晶出する固相の形態および固相率を算出した。

【0045】試験条件および試験結果を表1に示す。

【0046】

【表1】

表1

試験 No.	取鍋内のスラグ組成(質量%)							ΔAl (%)	タンディッシュ内の溶鋼中の全酸素量 (ppm)	鑄片の全酸素量 (ppm)	鑄片の清浄度 の指標 (-)1	スラグに 晶出する 固相の 割合 (%)	
	CaO	SiO ₂	Al ₂ O ₃	MgO	FeO	SiC	FeO-MgO						
本発明例	1	32.9	8.1	31.8	10.8	4.8	2.8	7.6	0.002	27	18	1.00	1.0
	2	38.1	8.9	29.1	12.1	7.8	3.2	11.0	0.002	24	18	0.98	2.3
	3	38.5	9.1	29.5	12.8	7.4	3.1	10.5	0.003	25	17	1.00	2.1
	4	37.4	7.4	35.2	12.4	3.5	1.9	5.3	0.002	24	18	0.97	1.5
	5	33.4	8.9	39.5	12.2	7.9	3.8	10.2	0.001	21	18	0.94	5.1
	6	49.2	8.1	25.6	16.1	6.6	3.2	8.8	0	22	18	0.82	8.7
比較例	7	39.6	8.1	30.3	6.7	2.6	3.8	9.4	0.01	45	35	1.45	0
	8	34.8	7.8	38.2	7.4	7.1	3.3	10.4	0.013	81	33	1.88	0

*1. 脱酸処理終了後の溶鋼中のAl含有率からタンディッシュ内の溶鋼中のAl含有率を引いた値。

【0047】本発明例の試験No.1~6では、脱酸処理終了後の取鍋内の溶融スラグの組成を本発明で規定する範囲の組成とした。これら試験での溶鋼の再酸化の程度を示す△Alの値は0.003%以下と低く、タンディッシュおよび鑄片の全酸素量も、それぞれ3.0および2.0ppm以下と低く、また、鑄片の清浄度も指数1.0以下であり、いずれも良好な結果であった。

【0048】脱酸処理終了後の取鍋内の溶融スラグ中のFeOおよびMgOの合計の含有率が1~1.1%と高いにも関わらず、溶鋼の再酸化が少なく、溶鋼の全酸素量および鑄片の清浄度などが良好であったのは、連続鍛造

開始後に取鍋内の溶融スラグに固相が晶出したためである。すなわち、組成を調整した後の溶融スラグの組成の分析値から熱力学的計算ソフトウエアを利用して算出した結果では、脱酸処理終了後から連続鍛造の開始までの間では、取鍋内の溶融スラグには固相が晶出せず、連続鍛造開始後から連続鍛造終了までの間で、MgO相の固相が1~9%程度晶出していることが推定できる。

【0049】とくに、固相が多く晶出していると推定される試験No.1~6および8では、△Alが低く、溶鋼および鑄片の全酸素量も低く、鑄片の清浄度指数も1.0以下以下の低い値で、良好な結果であった。

【0050】比較例の試験No. 7および8では、脱酸処理終了後の取扱内の溶融スラグの組成を本発明で規定する範囲外の組成とした。試験No. 7では、Mgの含有率が低く、試験No. 8では、さらに、Al₂O₃に対するCaOのモル比CaO/Al₂O₃が2未満であるにもかかわらず、Al₂O₃含有率が40%未満の、それぞれの溶融スラグの組成とした。そのため、連続鋳造の末期でも溶融スラグに固相が晶出しないと推定できた。

【0051】これら試験No. 7およびNo. 8での溶鋼の再酸化の程度を示すAl₂O₃の値は0.01%以上と高く、タンディッシュ内の溶鋼および鉄片の全酸素量も、それぞれ4.0および3.0 ppm以上と高く、また、鉄片の清浄度も指数1.00以上であり、いずれも悪い結果であった。

【0052】図1は、脱酸処理終了後の取扱内の溶融スラグの組成が溶鋼の再酸化に及ぼす影響を示す図である。連続鋳造中のタンディッシュ内の溶鋼中のAl含有率[A1]を脱酸処理終了直後の溶鋼中のAl含有率[A1]で除した値[A1]/[A1]と連続鋳造

時間との関係を、試験No. 1、2、6および8について示す。

【0053】溶融スラグに固相が晶出しないと推定される試験No. 8に比較して、溶融スラグに固相が1%でも晶出すると推定できる試験No. 1では、溶鋼の再酸化は抑制されており、さらに、試験No. 2およびNo. 6のように固相率が多くなるにしたがって、溶鋼の再酸化防止の効果が顕著となっているのが分かる。

【0054】

【発明の効果】本発明の方法の適用により、真空中での脱炭処理時の脱炭速度を損なうことなく、かつ取扱内の溶融スラグからの溶鋼の再酸化を抑制できる。また、連続鋳造の際に浸漬ノズルの損傷を防止でき、さらに、清浄性に優れた報紙炭素網を溶製することが可能である。適切な媒溶剤の選択により、復硫防止や復磷防止ができるることは言うまでもない。また、このような効果から製造コストの節減が可能となる。

【図1の簡単な説明】

【図1】脱酸処理終了後の取扱内の溶融スラグの組成が溶鋼の再酸化に及ぼす影響を示す図である。

【図1】

